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ORIGINAL ARTICLE

Wound conditioning by vacuum assisted closure (V.A.C.) in postoperative infections after dorsal spine surgery

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Abstract The use of vacuum assisted closure (V.A.C.) therapy in postoperative infections after dorsal spinal surgery was studied retrospectively. Successful treatment was defined as a stable healed wound that showed no signs of acute or chronic infection. The treatment of the infected back wounds consisted of repeated debridement, irrigation and open wound treatment with temporary closure by V.A.C. The instrumentation was exchanged or removed if necessary. Fifteen patients with deep subfascial infections after posterior spinal surgery were treated. The implants were exchanged in seven cases, removed completely in five cases and left without changing in one case. In two cases spinal surgery consisted of laminectomy without instrumentation. In two cases only the wound defects were closed by muscle flap, the remaining ones were closed by delayed suturing. Antibiotic treatment was necessary in all cases. Follow up was possible in 14 patients. One patient showed a new infection after treatment. The study illustrates the usefulness of V.A.C. therapy as a new alternative management for wound conditioning of complex back wounds after deep subfascial infection.

Keywords Spine · Instrumentation · Infection · Vacuum assisted closure · Topic negative pressure

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Introduction

Postoperative wound infection after spinal surgery is a serious problem that despite the use of prophylactic antibiotics advances in surgical techniques and postoperative care, compromise patient's outcome and results in significant morbidity and prolonged hospitalisation. Its incidence rate amounts to 0.4–20% [40, 59, 65, 66, 68], increasing with the complexity of the procedure being the highest for fusion with instrumentation [21,42, 57]. Most infections occur after posterior instrumentation [39, 69]. Last but not the least it increases the costs of the medical care four times compared to an uncomplicated case [7]. Management of infected spinal wounds was described in a variety of procedures. Some authors describe one-stage techniques by opening the wound, radical debridement, irrigation, primary closure and antibiotic treatment [12, 51, 55]. Also the use of antibiotic impregnated polymethylmethacrylate beads was reported [24]. Instrument removal of infected spinal wounds is recommended by some authors [55, 58, 62]. Irrigation–suction systems were also used in the management of infected spinal wounds [39, 42, 58, 61]. Delayed primary closure of the infected spinal wound up to wound healing by secondary intent are described procedures [59, 60]. Recently, some authors showed that instrumentation salvage is possible when techniques such as serial debridements, antibiotic medication, irrigation-suction systems and delayed primary closure of the wound are used [39, 42, 51, 54, 59, 60, 65]. Primary or delayed primary closure is often not possible and muscle flaps are required to close the dead space and to provide soft tissue coverage [15, 27, 46, 63]. The muscle flaps, however, as extensive surgical

procedures bear a significant morbidity for these critically ill patients [61, 69]. The debrided infected deep wounds after dorsal spine surgery were closed initially or left open, if doubtful, and packed for planed redebridement and then closed by delayed primary closure or covered early by muscle flaps.

The vacuum assisted closure (V.A.C.™, Kinetic Concepts, Inc., San Antonio, TX, USA) is a new efficient system for wound conditioning in treatment of problematic wounds [19, 22, 25, 36, 47, 48, 52]. Until now, this technique was applied in spinal surgery in one case report and one retrospective study only [44, 70].

In our retrospective study, we report our 2 years experience with the application of this technique as a new approach in the management of deep subfascial infections after dorsal spinal surgery based on temporary soft tissue coverage with reduction of the dead space and delayed primary closure of the wound.

Materials and methods

Between May 2002 and 2004, the dorsal spinal surgery was performed in our institution as an indication for a stabilization of traumatic and pathological fractures, decompression of spinal stenosis or stabilization for spondylolisthesis in degenerative diseases in 304 patients. Twelve patients developed subfascial infection (3.9%) and are reviewed retrospectively in this study together with three patients transferred to our clinic from other hospitals for treatment of the infection. The risk factors, comorbidities, history of previous back surgery as well as preoperative admission history, physical and medical consultation notes of the 15 patients (11 females, 4 males) with a mean age of 48 years (range: 18–75 years) were recorded. The time interval between initial operation and infection occurrence as well as the delay between spinal back infection and surgical treatment were estimated. In addition, the operative surgical and anaesthetic reports, management of perioperative antibiotic prophylactics, duration of the operation, estimated blood loss and the number of blood transfusions were noted. The infection was monitored by microbiological analysis of the causative organism and by the number of debridements. The preoperative levels of albumine and lymphocytes were estimated. The duration of the postoperative antibiotic treatment, the time before secondary wound closure and the patient's outcome were recorded as well. A wound infection was defined as superficial being limited to the subcutaneous tissue and dermis and having a negative intraoperative bacteriology of the subfascial space. As a deep one, the wound infection was defined by its extension beneath the lumbosacral fascia (Fig. 1a, b) and treated by meticulous debridement in the operating theatre, copious irrigation (Fig. 1c) and by closure with a V.A.C.™ system.

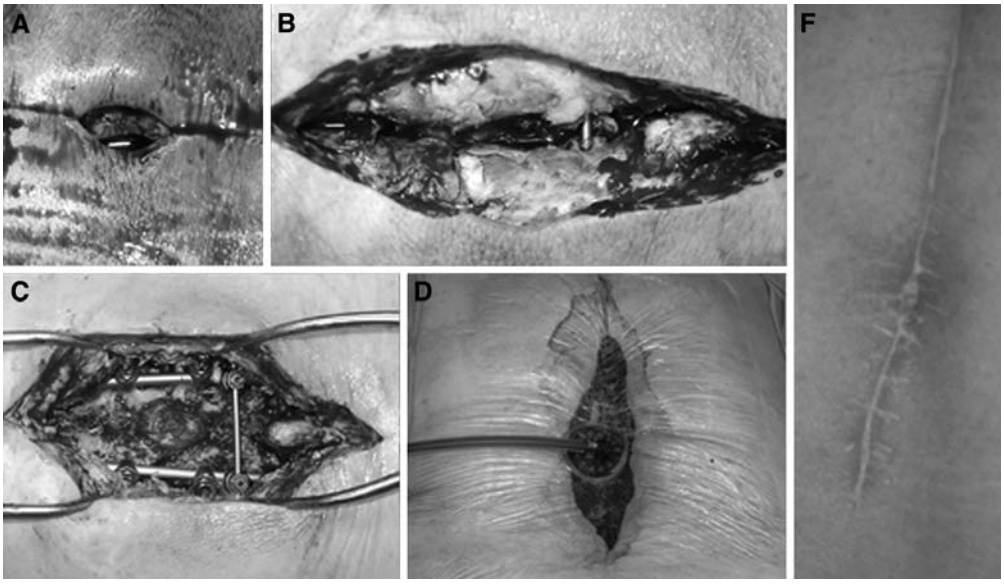

Fig. 1 The figure shows a wound fistula with secretion of a patient (No 11) 28 days after spinal instrumentation (**a**), a deep subfascial infection of the wound (**b**), a second look operation that included thorough debridement, implant redislocation and repeated irrigation with normal saline solution (**c**), the temporary coverage of the open wound during treatment of infection by V.A.C.™ system (**d**) and the final healing (**e**). Second look intervention with changes of V.A.C.™ were carried out in dependence of the wound and patients conditions

The V.A.C.™ system includes a black polyurethane soft foam cut to fit the wound and placed into the cavity to fill the entire wound dead space in several layers if necessary. A transparent adhesive gas- and fluid-impermeable plastic film is applied over the foam and about 4 cm of the wound surroundings to make an air-tight wound seal. A hole of about 2 cm diameter is cut into the center of the film and a specially designed adhesive TRAC™-PAD is fixed over it. The latter is attached to a suction tube via a container with an adjustable suction pump. A continuous negative pressure of 125 mmHg generates uniform negative pressure over the entire collapsed foam and draws the wound fluid from the wound into the foam and the container (Fig. 1d).

Scheduled operative interventions (second looks) included repetitive debridements, implant redislocation if necessary and irrigation with normal saline solution. These second look operations were carried out in dependence of the wound and patients conditions. This procedure was repeated until the soft tissue defect was free of necrotic tissue and macroscopically clean. The treatment was defined as successful when a healed stable wound was without further infection or signs of a chronic infection. All patients were evaluated in the course of a minimum of 12 months after definitive closure of the subfascial wound infection.

Results

Table 1 summarises the patient's risk factors, the comorbidities and the surgical procedures. Ten patients were initially operated for a closed fracture [two cervical (nos 12, 14), one thoracic (no 15) and seven (nos 2, 3, 5, 7, 9, 10, 13) thoraco-lumbar spine]. Two patients (nos 1, 11) had a myelon compression and incomplete neurological deficit classified as Frankle C and B, respectively, due to tumour infiltration into the thoracic spine at the level of Th 8 and Th 12 respectively [23, 43]. The spinal metastasis according to histology was derived from a prostate and an invasive ductile breast cancer. Three patients (nos 4, 6, 8) had previous back surgery, developed deep postoperative infection and were transferred to our clinic. One patient (no 4) had scoliotic deformity of the thoracolumbar spine. Two patients (nos 6, 8) had spinal stonsis of the lumbar spine. Neurological deficiency was estimated in patient no 4 (Frankle A), in patients no 6 and 8 (Frankle D) and in patient no 9 (Frankle B). Cephalosporins of the second generation were used as initial intra-operative antibiotic management in all patients. Additional ventral instrumentation was performed within a mean time of 29 days (range: 4–110 days) after dorsal spinal surgery, six with Synex Cage™ (Synthes®, Stratec Medical, 4436 Oberdorf, Switzerland) and one with PMMA (Palacos™ cement plumb, Essex Chemie AG, 6005 Luzern, Switzerland).

All 15 patients developed a deep subfascial infection after dorsal spinal surgery. During the first surgical intervention the antibiotic therapy was started after bacteriological sampling. In the further course of treatment, after obtaining the microbiological results, the antibiotics were adapted according their resistance proof after consultation with the infectiologist in our institution. The results of bacteriological cultures, antibiotics therapy and surgical management are summarised in Table 2. Except one patient, all infections were early ones (Table 2) [71]. Two of the three transferred patients showed a significant delay in the beginning of surgical treatment (Table 2). The infections were mostly caused by gram-positive organisms and more than one bacteria was isolated in five patients. In two-thirds of the infections, the antibiotic management had to be changed because of occurring resistance. In two patients (nos 1, 9) the antibiotic management was extremely long because of immune deficiency of tumour progression and they spread infection into the ventral stabilisation (Table 2). The preoperative levels of serum albumin were 30.7 ± 2.28 g/l (range: 20–34 g/l) and the lymphocyte count amounted to $1.1 \pm 0.16 \times 10^3/\mu l$ (range: 0.4–$2.7 \times 10^3/\mu l$). The operation time ranged from 110 to 320 min (mean 200 min) and mean intra-operative blood loss was 1,900 ml (range: 400–10,000 ml). The haemoglobin level dropped from 11.3 ± 0.53 g/l (preoperative values) to 8.9 ± 0.41 g/l (postoperative values). Blood transfusion amounted to seven units (range: 2–18 units) in an average in four patients (nos 1, 9, 11, 15). A severe intra-operative bleeding was encountered in one patient (no 1). All 15 patients after bacteriological sampling underwent surgical debridement and copious irrigation with saline fluids.

All patients, except two (nos 4, 5), were transferred postoperatively to the intensive care unit (ICU) with a mean stay of 5 days (range: 1–25 days).

V.A.C.™ dressing was changed after 3 days in an average (range: 1–7 days) only during repeated second look operations and performed 3.8 times in an average (range: 1–13 times). The duration of V.A.C.™ therapy is summarised in Table 2. Bacterial cultures were negative after a mean time of 8 days (range: 2–13 days).

All implants used except that the Harrington rod was of titanium. The implants were left in place during the first surgical intervention for spinal back infection.

Table 1 Patients' clinical data

Patient no.	Risk factors and comorbidities										
	Polytrauma (ISS)[a]	Nicotine	Alcohol	Tumour	Adipositas (BMI)[b]	Diabetes	Radiation before surgery	Arterial hypertension	Chronic renal failure	Coronary heart disease	Chronic obstr. pneum. disease
1				+			+				
2	41										
3					36	+					
4					39						
5	34	+	+								
6					28	+		+	+		
7						+		+		+	
8					34		+			+	
9	29										
10	34										
11		+	+	+	32						+
12			+						+		
13	17										
14	17				59						
15	21										

Patient no.	Implant						Surgery				
	AO-USS fixator	AO-USS side opening fixator	Harrington	Plate	Screw	Cerclage	Laminectomy	Costo-transversectomy	Spondylodesis	Bone graft iliac crest	Bone graft local bone
1		+						+			
2	+										
3		+									
4			+								
5	+										
6							+				
7	+										
8							+		+		
9	+						+			+	
10	+										
11		+					+	+	+		
12					+	+				+	
13	+										
14				+			+		+		+
15		+					+		+	+	

[a]Injury severity score [5]

[b]Body mass index (kg/m^2)

Table 2 Microbiology, antibiotic therapy and surgical management

Patient no.	Delay between first operation and infection (days)		Organism[b]	Gram positive	Gram negative	First antibiotic therapy[c]	Change of antibiotic therapy (days)	Final antibiotic therapy[c]	Duration of antibiotic therapy (days)	Number of surgical interventions	Implant removed	Implant changed	Implant left in place	Number of VAC changes	Duration of VAC therapy (days)
	Early[a]	Late[a]													
1	19		Sa	+		A	7	C,R	249	5		+		4	11
2	6		Bc, Cl sp		+	P,R,V	31	A,C	68	2		+		1	3
3	10		Sa	+		C,R	–	–	90	3		+		2	5
4	29		E, Ec	+	+	C,R,V	–	–	57	7	+			6	24
5		124	Sa	+		A	–	–	40	4	+			3	7
6	3		Ea, Ecl,E	+	+	P	44	C,V	93	14				13	64
7	15		Sa	+		F	–	–	30	3	+			2	5
8	51		E,Pa, St	+	+	P,V	40	M,V	99	8				7	24
9		136	Pa		+	C,M	–	–	303	2	+			1	3
10	10		Sa	+		P	2	C,F,R	55	4			+	3	14
11	28		Scn	+		C,R	9	G,R,V	92	4		+		3	12
12	7		Scn, E	+		Ce	3	A,G	69	6		+		5	9
13	12		Sa	+		A	9	L,R	47	3		+		2	5
14	11		Pm		+	A	6	C	77	4	+			3	9
15	12		Sa	+		C,R	13	C,R,V	95	3		+		2	6

[a] [71]

[b] Sa *Staphylococcus aureus*, Bc *Bacillus cereus*, Cl sp *Clostridium sp*, E *Enterococcus*, Ec *Escherichia coli*, Ea *Enterobacter aerogrenes*, Ecl *Enterobacter cloacae*, Pa *Pseudomonas aeruginosa*, St *Streptococcus*, *Scn* coagulase-negative Staphylococcus, Pm *Proteus mirabilis*

[c] *A* aminopenicillin combined with clavulanic acid, *C* ciprofloxacin, *Ce* cefepim dihydrochloride dihydrate, *F* sodium flucloxacillin, *G* gentamicin, *L* levofloxacin, *M* meropenem trihydrate, *P* piperacillin + tazobactam, *R* rifampicin, *V* vancomycin

The connecting parts of the internal fixator in four patients (nos 1, 11, 13, 15) and the cerclage wire in one patient (no 12) were exchanged within a mean time of 9 days (range: 4–12 days) during one of the second look operations. The internal fixator systems were completely exchanged in two patients (nos 2, 3) after 3 and 5 days respectively. The new implants of these two patients were of titanium as well. In five cases the implants (1 × Harrington rod, 3 × internal fixators, 1 × plate) were completely removed in average after 45 days after initial instrumentation without reinstrumentation (range: 9–143 days). The cause for complete removal of two internal fixators and one plate was the loss of stability of instrumentation.

Delayed primary closure without additional reconstructive surgery was performed in 13 patients. In two patients (nos 6, 8), a local muscle rotation flap with mesh grafting was necessary for definite wound closure. One of them (no 6) developed a partial necrosis of the flap that was successfully managed by means of V.A.C.™ dressing. When sufficient granulation tissue was formed, another mesh graft could be performed and the wound was healed. The average hospital stay was 43 days (range: 16–118 days).

Follow-up was possible in 14 patients after 28.9 months in an average (range: 15–40 months). One patient (no 8) refused a control visit as outpatient and was not available for a follow-up. Two patients (nos 2, 13) were transferred postoperatively to their native country and were contacted by phone call. All wounds were stable except one (no 4), which 169 days after the first diagnosis of infection developed a new one which was then treated with repeated debridements, irrigation and V.A.C.™ dressing. The wound healed then eventless.

Discussion

Postoperative infections after spine surgery have been reviewed in terms of occurrence rate, complications, microbiology and surgical technique [8, 11, 17, 31, 33, 40, 59, 65, 69]. The risk factors compromising local perfusion and thus predisposing an infection are diabetes, smoking, alcohol abuse, immune deficiency in case of malignancy, morbid obesity, cardiovascular problems and radiation before surgery [24, 42, 60]. A recent study described that trauma patients enter a catabolic state after an injury and emphasised the importance of monitoring the caloric intake and of securing positive protein balance [30, 54]. The risk of an infection in patients undergoing spinal surgery diminishes if the albumin level is higher than 35 g/l and the total lymphocyte count is greater than 1.5–2.0 × 10^3/μl [24]. In our study, the trauma was a risk factor for catabolic situation in seven patients. The above mentioned further risk factors were also present in our study group (Table 1). In addition, all patients who developed an infection had lower levels of albumin and, except one, showed a lymphopenia.

The flap coverage is the standard treatment of infected wounds after spine surgery [9, 14, 15, 27, 32, 41, 45, 46, 63, 66]. The use of omental transposition in the treatment of recurrent sarcoma of the back was also described [38]. The flap closure, however, is accompanied with significant morbidity, including extended operative time, blood loss, recurrent infection, dehiscence, flap failure, seroma, donor site morbidity, significant comorbidities and poor tissue characteristics that complicate the wound healing or compromise the chosen flap [18, 61, 69]. Recently, several authors reported successful management of postoperative infection after spinal instrumentation without flap coverage [12, 24, 29, 33, 39, 42, 51, 53, 59, 61, 65, 68]. Such a treatment includes repetitive debridements, delayed closure, local irrigation system, antibiotic medication and maintenance of the instrumentation system. Nevertheless, this approach was designated as inappropriate on an example of 13 of 19 patients who developed local wound complications, persistent infection, wound dehiscence, seroma or haematoma [67]. Debridement without removal of the implant combined with prolonged intravenous antibiotic treatment and subsequent long-term oral antibiotic therapy has a failure rate between 32 and 86% [71]. Others, on the other hand, prefer removal of the instruments to eradicate the infection that followed the instrumented spinal fusion [1, 4, 13, 55, 56, 62]. Another possibility is instrumentation removal in case of late deep infection, debridement and new reinstrumentation to achieve permanent correction for scoliosis [50]. These are well known options for implants with infections either by complete removal or one (implant change) or two stage (removal and delayed reimplantation) procedures [6, 26, 28, 71]. In an experimental study, the rate of infection for steel plates was significantly higher than that for titanium plates [2]. The bacteria within matrix-enclosed communities (biofilm) are protected against host defence and antibiotics, and clinical experience has shown that they must be removed and compromised tissue must be debrided before the infection can be resolved [10, 16]. According to the above mentioned procedures of infected implants, their metallic composition and the known effect of the biofilm, in our clinic, usually remove or exchange the implants by one or two stage procedures.

Anyhow, the key component of a successful treatment of infections after dorsal spine surgery, in our opinion, is the operative management with repetitive second look operations and copious debridement. We are not using local irrigation systems for infected wounds, because in view of our observations they are insufficiently limiting the irrigation to a small part of the wound only. The application of V.A.C.™ dressing in infected wounds after spine surgery was hitherto documented in one case report [70]. A recently published study describes treatment of 20 patients with deep wound infections after dorsal spinal fusion [44]. The authors performed repeated debridements in 12 of 20 patients without resolving the infection before they applied V.A.C.™ dressing for the wound conditioning. After 2 to 3 V.A.C.™ dressing changes they arrived then to delayed primary closure of the wounds. We started the V.A.C.™ therapy in this study directly during the first surgical intervention following our own experience with V.A.C.™ dressing in management of severe soft tissue problems [34–37].

The V.A.C.™ dressing as a technique for reduction of the dead space and for the wound conditioning has several merits. The temporary closure prevents contamination and desiccation of the wound and protects it towards injury. The drainage of an open wound under negative pressure and V.A.C.™ dressing is more efficient than local irrigation systems by continuously removing the wound fluid which inhibits mitosis, protein synthesis and fibroblast collagen synthesis [3] and prevents its stasis in the wound. The drainage of extracellular fluid also reduces the interstitial pressure, increases blood flow and thus the local nutrition as well [3]. The topic negative pressure therapy reduces the expression of matrix metalloproteinases in chronic wounds and promotes healing [20]. The mechanical stimulation of cells probably influences positively the healing of the wound. The question of V.A.C.™ influence on bacterial clearance has still remained opened [48, 49, 64].

In conclusion, V.A.C therapy is a valuable alternative new technique for management of dead space and wound conditioning in infections after dorsal spine surgery.

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